chiller ACES. Three harvest schemes were tested: hot-gas, stored-refrigerant and dual fluid off-cycle. The hot-gas scheme tended to penalize excessively the heating output of the system. Stored-refrigerant schemes eliminated that problem but caused compressor failures due to floodback and oil dilution. The dual-fluid schemes exhibited no such problems and demonstrated an ability to harvest during compressor off-cycles. Therefore, it is concluded that dual-fluid off-cycle schemes are the best for use with IMHPs using hermetic compressors. Ice packing density measurements indicate a maximum packing factor for plate ice from IMHPs of 0.4 compared to 0.8 for brine-chiller systems. Having the ice distributed evenly in water was found to give better packing factors than allowing it to pile up under the plates. A survey of commercial ice makers indicates that IMHPs producing cylindrical or cubical ice rather than sheets would have packing factors of 0.58 to 0.66 with obvious economic benefits. However, the cost of evaporators for making such ice is not likely to be economical. Larger storage bin requirements make plate-type IMHP systems significantly more expensive than brine-chiller systems in most cases.

2. The Development of an Air-Icemaker Multiple Source Heat Pump System, M.H. Somerville, Dept. of Mech. Engr., Univ. of Arkansas, Fayetteville, AR; **S. G. Penoncellow,** Univ. of North Dakota, Grand Forks, ND.

A multiple source heat pump system utilizing an air evaporator and ice-makers has been built and laboratory tested. Details of the testing procedure and the results of the tests are presented. The tests revealed the need for a larger expansion valve in the system, and a heat exchanger accumulator rather than a conventional refrigeration accumulator. The details of these findings are discussed. At the time of this writing, the heat pump is being installed in the experimental house which belongs to Mr. Dick Widseth.

3. Project Icebox—Annual Energy Storage System, J. Klassen, Member ASHRAE, Chief, Energy Secretariat, Public Works Canada, Ottawa, Ontario, Canada.

Not available at time of printing.

SYMPOSIUM CH-81-24 SOLAR APPLICATIONS TO AGRICULTURE

Chm.—**Dr. L. D. Albright,** Member ASHRAE, Assoc. Prof., NY State Coll. of Agr. & Life Sciences, Cornell Univ., Ithaca, NY (Sponsored by TC 67 and TC 2.2; PCL.—W.C. Stethem and D.P. Gatley)

The symposium theme is contained in its title—to focus on the special problems of applying solar technology to production agriculture. Because agricultural applications involve intimate association with biological systems, special problems arise in designing appropriate solar systems. Also, cost is an overriding concern, which leads to different criteria in design of solar systems. This Symposium proposes first to describe collector design considerations, then applications of solar systems to animal and plant production facilities.

1. Solar Collector Design for Agricultural Applications, Dr. B. F. Parker, Prof., Univ. of Kentucky, Lexington, KY.

Solar collector design is of particular concern in agriculture where heated air can be utilized for space heating of animal structures, grain drying, and residential heating at a range of temperature levels depending on the application, location, and the time of year. Therefore, several designs for collectors which produce heat at different temperatures can be utilized. Construction methods which appear to have the greatest merit are to build long air-type collectors between purlins as the structure is assembled. Analytical design procedures, using recently developed equations for three basic collector types, provide the basis for predicting thermal performance of air-type collectors. Several solar air heater design examples are also presented.

2. Solar Energy Applications in Animal Housing, Dr. J.P. Mason, Prof., Virginia Tech., Blacksburg, VA.

Solar energy applications for animal housing have been found to be advantageous for swine, poultry, and dairy (milking). Heating water and space heating are the most frequent requirements. Adapting solar systems to environmentally controlled confinement housing for agricultural animals requires general solar technology modified for the specific problems associated with livestock shelters. Systems developing across the nation are typically flat plate collectors using air, water, or a combination of the two. Storage may or may not be included. Energy is delivered by heating the ventilating air, by heating portions of concrete floor slabs, or by convectors. Controls employed are conventional, but ventilating requirements of an animal environmental must be satisfied. Economic feasibility is only marginal, but fuel costs will govern. Knowledge and experience being gained are considered significant to the future of agricultural animal production. Farmer interest is rapidly increasing and is reflected by willingness to invest in solar energy systems on farmsteads cooperatively with research/demonstration programs or totally with personal funds.

3. Solar Applications for Heating Commercial Greenhouses, Dr. L. D. Albright, Member ASHRAE, Assoc. Prof., NY State Coll. of Agr. & Life Sciences, Cornell Univ., Ithaca, NY.

The current state of space-heating commercial greenhouses with solar energy is reviewed. Selected projects from numerous locations in the U.S. are reviewed briefly, projects which illustrate the various approaches to solar heating. Techniques include: external collectors, integral greenhouse/solar collectors, and passive solar heating systems. Short term as well as long term thermal storage is being investigated. Although no project yet has a system ready for commercial adoption, several possess promising features. To be adopted, the solar system must: (1) provide a relatively short payback. (2) not interfere with the ability of the grower to produce a high quality crop without excessive delays, and (3) be coordinated with all reasonable energy conservation measures.

FORUM: BELOW GRADE INSULATION AND HEAT TRANSFER

Mod.—**Dr. F. S. Wang,** Member ASHRAE, Res. Spec., Dow Chemical U.S.A., Midland, MI.

Heat loss (gain) from the slab floor or below grade foundation wall has long been ignored in the past. With energy conservation measures already implemented in other parts of a conditioned structure, such heat loss becomes a significant portion of the total energy consumption. In most cases, such areas had no insulation to begin with, and therefore they become the most efficient place to install insulation. Because of the complicated geometry involved, there has been no reasonably accurate design method. In the last few years, field tests and experiments have been carried out at several institutions. Also computer programs have been written to simulate such two dimensional heat flow problems. It is very timely to bring all the researchers together to share and discuss their results. Also it is most appropriate to have the engineers, architects, and regulatory agents together to develop general consensus.

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